SOUTHWARK HOSPITAL.

Lectures to Nurses

By H. W. BRUCE, M.D.

1923.

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Anatomy and Physiology.

Lecture I.

Anatomy is the science which teaches the shape, position and structure of the different parts or **Organs** which make up the human body.

Physiology is the science which teaches the functions of these organs, and the ways in which those fnctionus are performed.

The body consists of the **Trunk** and the **Limbs.**

The **Trunk** is made up of the **Head,** the **Neck,** the **Thorax** or **Chest** and the **Abdomen.**

The **Limbs** are:—

1st.—The **Upper Extremities,** each consisting of the **Shoulder, Arm, Forearm** and **Hand.**

2nd.—The **Lower Extremities,** each consisting of the **Hip, Thigh, Leg** and **Foot.**

GENERAL STRUCTURE OF THE BODY.

By dissection the human body is found to be made up of many different parts, each of which has its own particular duty to perform. These parts are called **Organs.**

Thus the **Heart** is an organ whose function is to pump the blood along the blood vessels. The **Skin** is an organ whose function is to cover and protect the body, and so on with all the parts which make up the human frame.

When a **Limb** is dissected it is found to be covered on the outside by the **Skin.** Beneath the skin is a material which binds it with varying firmness to the muscles or bones lying underneath. This material is called **Connective Tissue** because its function is to connect together different organs. It is composed of a network of fibres or threads, and the connective tissue under the skin contains a greater or less amount of fat.

Under the connective tissue are the **Muscles,** red in colour and commonly called "flesh."

They surround the solid central framework formed by the **Bones.**

The muscles make up the chief bulk of the limb.

The **Trunk** in the same way has a covering of skin, underneath which are connective tissue, muscles, and a certain amount of bony framework. These together are called the walls of the **Cranium,** of the **Thorax,** and of the **Abdomen,** and they shut in large cavities. That in the head is called the Cranial Cavity, that in the chest the Thoracic Cavity, and that in the abdomen the Abdominal Cavity.

These cavities contain many important organs. Thus the Cranial Cavity contains the **Brain,** the Thoracic Cavity contains the **Heart** and **Lungs,** and the Abdominal Cavity the **Liver, Stomach, Intestines,** etc.

All the organs of the body have running through them a network of tubes, the **Blood Vessels,** and also a number of solid white cords of varying size, which are the **Nerves.**

MINUTE STRUCTURE OF THE BODY.

Although there are many different organs they are all found to be composed of only a small number of substances which are called **Tissues,** just as the various parts of a building are made of only a few materials.

Thus all the organs are composed of one or more of the following substances or Tissues:—

Epithelial Tissue.
Connective Tissue, often containing **Fatty Tissue.**
Muscular Tissue.
Nervous Tissue.
Bone and **Cartilage** (or Gristle).
Blood and **Lymph.**

For example, the **Heart,** a thick-walled bag, is composed chiefly of **Muscle,** with a lining of **Epithelial Tissue,** and all bound together by **Connective Tissue.**

The Tissues, when examined under the microscope, are found to be composed of separate minute, but generally regular masses called **Cells,** and of fibres.

In the case of Bone, there is, in addition, a hard solid substance, in the case of Cartilage, a peculiar clear substance, and in the case of Blood and Lymph, a fluid substance placed between the cells.

COMPOSITION OF THE BODY.

An almost innumerable number of different substances occur in nature, but they can be all broken up into simpler substances until only about 60 remain that cannot be further broken up and are called **Elements.**

The human body is composed of about **15** of these elements, of which the chief are **Carbon, Hydrogen, Oxygen,** and **Nitrogen.**

COMMON TERMS OF POSITION.

In describing the position of any part of the human frame, the body is invariably considered to be standing erect with the arms by the sides and the palms of the hands facing forwards.

The body being in that posture, the upper surface of any part is called the **superior** surface and the lower the **inferior** surface.

In the same way a part is said to be superior to another part which is below it, and inferior to a part which is above it.

The front surface of any part is called the **anterior** surface and the back the **posterior** or **dorsal** surface.

The sides are called the **lateral** surfaces.

If one point be in front of another point it is said to be anterior to it, and, if behind it, posterior to it.

Middle Line. This is an imaginary line drawn down the centre of the body from the top of the head to midway between the heels.

A part which is nearer this line is said to be **internal** to a part which is further away.

Conversely a part which is further away from this line is said to be **external** to a part which is nearer.

The same terms are applied to the lateral surfaces of parts. The surface which is nearer to the middle line is the internal surface and that which is more distant is the external surface.

Lecture II.

THE SKELETON.

THE BONES.

The solid framework of the body is formed by the **Bones,** which are bound together by tough fibrous bands called **Ligaments.**

The Bones are of various shapes, **Long, Short, Flat** and **Mixed.**

Bone is made up as follows:—

1st.—An outer tough fibrous covering, the **Periosteum.**

2nd.—**Hard Bone,** which is of two kinds—(a) **Compact Bone,** hard and close grained; and (b) **Cancellous Bone,** more open and sponge-like in texture.

3rd.—A central soft substance, the **Medulla** or **Marrow.** Each of these has blood-vessels and nerves running through it.

Common Terms Used in Describing Bones.

A smooth surface at the end of a bone which helps to form a joint is called an **Articular Surface.** A rounded Articular Surface is called a **Head.** When the next part of the bone is narrowed, the narrow portion is called a **Neck.**

A perforation is called a **Foramen.**

A rough prominence is, if broad, called a **Tuberosity** or sometimes a **Trochanter.** A narrower one is called a **Tubercle.** A still sharper one is called a **Spine.**

THE SKULL.

The Skull consists of the **Cranium** or Brain Pan and the **Face.**

The **Cranium** enclosing the Cranial Cavity is a strong bony box which contains and protects the **Brain.** It is made up of eight bones most of which are flat bones. In the adult these flat bones are immovably interlocked together and the interlockings are called the **Sutures of the Skull.**

The Superior or upper surface of the Cranium is called the **Vault** and the Inferior or lower surface is called the

Base. The Base especially is perforated by many Foramina of varying size.

The Bones of the **Cranium** are:—

1. The **Frontal Bone** forming the Forehead and the front part of the vault of the skull. Its lower edge in front forms the two **Supraorbital Ridges** which constitute the upper margins of the Orbits.

2.—The two **Parietal Bones,** one on each side, forming the upper part and the sides of the vault.

3.—The two **Temporal Bones.** Each consists of three parts:—

1st.—A Flat Portion which forms the lower part of the side of the vault.

2nd.—A Solid Portion which contains the Organ of Hearing, and

3rd.—A rough process, called the Mastoid Process, situated behind the Ear.

4.—The **Occipital Bone** forming the Posterior part of the vault and curving round to form also part of the Base of the Cranium. The latter part shows a very large perforation, the **Foramen Magnum,** which is the communication between the Cranial Cavity and the Spinal Canal. On each side of the Foramen Magnum are the articular surfaces for the Atlas.

5.—The **Sphenoid Bone** forming the Base of the Skull in front of the Occipital Bone, and in front entering into the Orbits. It is shaped like a bat with extended wings.

6.—The **Ethmoid Bone** situated between the two Orbital Cavities and forming part of the bony wall of each. It is perforated by the branches of the Olfactory Nerves and below extends into the Nasal Cavities.

The junction of the two Parietals and the Frontal is at birth still cartilaginous and is called the **Anterior Fontanelle.** It should be completely closed at the age of 18 months. In children with rickets its closure is often delayed.

The junction of the Parietals and the Occipital is called the **Posterior Fontanelle.** This is usually closed at birth.

Viewed from the inside the Base of the Cranium presents three compartments which are called Fossæ.

Bones of the Face. The **Face** is joined to the Base of the Cranium.

Fourteen bones enter into it, two single ones and six pairs, and it is made up chiefly of the two **Orbits,** the two **Superior Maxillæ** and the **Inferior Maxilla.**

The **Orbits** are bony cavities of pyramidal shape. They are formed by several bones, of which the chief are the Frontal, the Ethmoid, the Superior Maxillæ and the Malar Bones.

The Orbits contain the Eyeballs, the muscles which move the eyeballs and some fatty tissue which acts as a packing. The eyes are thus sunk in bony sockets and are thereby protected from injury.

The Optic Nerves pass through bony foramina from the Brain into the Orbits, to enter the Eyeballs.

The two **Superior Maxillæ** together form the **Upper Jaw** and they enclose between them the **Nasal Fossæ,** which form the cavities of the Nose. The lower surfaces of the Superior Maxillæ form the **Hard Palate,** while their lower borders form the **Alveolar Margin** which carries the upper teeth.

The **Nasal Cavities** or **Nasal Fossæ,** right and left, are situated between the two Superior Maxillæ. They are separated from one another by a thin partition, the Septum Nasi.

The **Inferior Maxilla** or **Mandible** consists of a Body and two **Rami.** The **Body** is in front and carries the lower teeth. Each **Ramus** is square shaped and flat. From its upper edge project two processes. The one in front called the **Coronoid Process** forms the insertion of the Temporal Muscle. The one behind presents an articular surface the **Condyle,** which fits into an articular cavity in the Temporal bone to form the **Temporo-Maxillary Joint.**

The **Teeth** appear at the following dates.

The Temporary Teeth at the 7th, 9th, 18th, 12th, 24th month.

The Permanent Teeth at the 7th, 8th, 11th, 9th, 10th, 6th, 12th, 18th year.

The order of these dates applies to the teeth beginning at the middle line and going outwards.

The two **Malar Bones** form the bony prominences of the Cheek, and help to form the Orbits.

The two **Nasal Bones** form the upper bony part of the Nasal Prominence.

Lecture III.

SKELETON (cont.)

THE VERTEBRAL COLUMN.

The **Vertebral** or **Spinal Column** or Backbone forms the central pillar of the body. It is composed of thirty-three bones called **Vertebræ.** Some of these become fused together, so that in the adult there are only twenty-six separate bones.

Each Vertebra consists of a solid mass in front called the Body of the Vertebra, and a bony ring behind. These rings placed one above the other form a canal, the **Spinal Canal,** which is occupied by the **Spinal Cord.**

Projecting from each ring behind is a process, the **Spine** or **Spinous Process,** which can be felt in the back.

The Vertebræ are divided into the following five groups, according to the part of the body in which they are situated:—

1st.—Seven **Cervical Vertebræ** in the Neck.
2nd.—Twelve **Dorsal Vertebræ** at the back of the Thorax.
3rd.—Five **Lumbar Vertebræ** at the back of the Abdomen.
4th.—Five **Sacral Vertebræ** at the back of the Pelvis. These are fused into one bone in the adult.
5th.—Four **Coccygeal Vertebræ** fused into one bone.

These bones are bound together by strong ligaments and by pads of cartilages placed between their bodies, so as to form a column which has four curves.

The **Cervical Curve** convex (or bulging) forwards;
The **Dorsal Curve** concave (or hollowed out) forwards;
The **Lumbar Curve** convex forwards; and
The **Sacral Curve** concave forwards.

The Vertebræ are jointed to one another so as to allow some amount of movement, and thus the Spinal Column is

pliable. It is nevertheless made very strong by the powerful ligaments which bind the vertebræ together, and in this way the Spinal Cord, which is essential to life, is protected and is very seldom injured.

Cervical Vertebræ—

The 1st or **Atlas** supports the skull on two large articular processes.

The 2nd or **Axis** has the tooth-like Odontoid Process projecting upwards.

Dorsal Vertebræ.—The Ribs are attached and jointed to these vertebræ.

Lumbar Vertebræ.—Are very large and strong.

Sacral Vertebræ.—These five vertebræ are fused together to form one wedge-shaped bone called the **Sacrum,** which is placed between and attached to the two Ossa Innominata or Hip Bones.

Coccygeal Vertebræ are fused into one small bone called the **Coccyx,** which is attached to the Sacrum. In the lower animals they enter into the tail.

THE THORAX.

The **Thorax** is a bony cage enclosing the thoracic cavity.

The bones which form its walls are the **Dorsal Vertebræ** behind, the **Sternum,** or breast bone in front, and the **Ribs** on each side sloping downwards and forwards from the Spine.

The spaces between the bones are filled up by muscles and membranes.

The **Ribs** are 24 in number, 12 on each side. They articulate behind with the Dorsal Vertebræ and thus are movable to a certain extent.

In front their attachment varies. The first 7, which are called **true Ribs** are attached directly to the Sternum by their cartilages, the **Costal Cartilages,** thus forming 7 complete circles.

The lower 5, called **false Ribs,** are not directly attached to the sternum.

Nos. 8, 9 and 10 are fixed by means of their cartilages to the cartilages of the ribs next above. The anterior ends of Nos. 11 and 12 are free and these are called **floating ribs.**

The **Sternum** or breast bone is a sword shaped bone to which on each side the upper 7 ribs are attached by means of their cartilages. Its upper end articulates with the two clavicles. Its lower portion is formed by the **Xiphoid Cartilage.**

The **Thoracic Cavity** contains the **Lungs** one on each side and the **Heart** placed between the two. It also contains the great **Blood Vessels,** part of the **Œsophagus** or Gullet, part of the **Trachea** or Windpipe and the **Thoracic Duct.**

ATLAS has no body simply a ring of bone with spinous and transverse processes

AXIS: - ① dontoid process passes through the ring formed by the atlas - and the atlas turns on this process

Lecture IV.

SKELETON (cont.)

BONES OF THE UPPER EXTREMITY.

The **Clavicle** or Collar Bone is a doubly-curved rod articulated or jointed at its inner end to the upper end of the Sternum and at its outer end to the Acromion Process of the Scapula.

—The **Scapula** or Shoulder Blade is a triangular bone placed on the back of the thorax over which it moves. It is kept in position by muscles attached and by being jointed to the Clavicle.

It consists of a triangular flat portion and a prominent ridge called the **Spine** which projects from the posterior surface

The Spine runs out into the **Acromion Process** with which the Clavicle articulates.

At the outer and upper angle of the Scapula is a shallow pear-shaped articular surface, the **Glenoid Fossa,** which forms with the Humerus, the **Shoulder Joint.** The joint is protected above by the Acromion Process.

The **Humerus,** the long bone of the arm consists of—

1st.—The **Shaft** with a groove behind for the important **Musculo-Spiral Nerve.**

2nd.—The **Upper Extremity** presenting the rounded articular **Head** which, with the Glenoid Fossa of the Scapula, forms the **Shoulder Joint,** and two rough **Tuberosities** between which the tendon of the Biceps muscle runs.

3rd.—The **Lower Extremity** which presents two articular surfaces for the two bones of the forearm. That on the outer side for the **Radius** being rounded and called the **Capitellum** and that on the inner side for the **Ulna** shaped like a pulley wheel and therefore called the **Trochlea.** The **Elbow Joint** is formed by the articulation of these three bones.

The lower extremity of the Humerus also presents two projecting processes the **External Condyle** on the outer side and the more prominent **Internal Condyle** on the inner side.

The bones of the Forearm are the **Radius** and **Ulna** lying parallel to one another.

The **Ulna** is on the inner side and consists of—

1st.—The **Shaft** with a sharp posterior border which can be felt under the skin.

2nd.—The **Upper Extremity** which articulates with the Trochlea of the Humerus. It consists partly of the **Olecranon Process** which projects upwards and forms the point of the elbow.

3rd.—The **Lower Extremity** which is small and ends in the **Styloid Process** which can be felt on the inner side of the wrist.

The **Radius** is on the outer side of the forearm and consists of—

1st.—The **Shaft.**

2nd.—The **Upper Extremity** round and hollowed into a shallow articular cavity to fit on to the Capitellum of the Humerus.

3rd.—The **Lower Extremity** which is expanded and has a large articular surface which forms with the **Carpal Bones,** the **Wrist Joint.**

On the outer side the **Styloid Process** projects downwards.

The Bones of the **Wrist** or **Carpus** consist of the 8 **Carpal Bones** arranged in two rows.

The upper row articulates with the Radius to form the wrist joint, the lower row articulates with the **Metacarpals** and the two rows also articulate together.

The Bones of the **Palm** are the 5 **Metacarpals** of which the first, belonging to the thumb, is the most movable.

The bones of the **Fingers** are the **Phalanges** two in the thumb and three in each finger. They are numbered First, Second, and Third starting from the palm.

BONES OF THE LOWER EXTREMITY.

The **Os Innominatum** or Hip Bone is a flat bone presenting near its centre a deeply hollowed out articular surface, the **Acetabulum,** into which the Head of the Femur fits, forming the **Hip Joint.**

The Os Innominatum is formed in infancy of three bones the **Ilium,** the **Ischium** and the **Pubes** arranged around the Acetabulum.

Of these the **Ilium** is above. Its upper edge which is called the **Crest of the Ilium** terminates in front in the **Anterior Superior Spine of the Ilium.** Behind, the Ilium articulates with the Sacrum.

The **Ischium** is below and is partly formed of the rough **Tuberosity of the Ischium** upon which pressure comes in sitting. The **Pubes** is in front and attached to its fellow of the opposite side, thus completing the **Pelvic Ring** composed of the Sacrum behind and the two Ossa Innominata at the sides and in front.

The **Pelvis** is a basin shaped cavity bounded in front and at the sides by the two **Ossa Innominata** and behind by the **Sacrum** and **Coccyx** wedged in between them.

The cavity of the Pelvis represents the lower part of the Abdominal Cavity and is divided into an upper shallow part the **False Pelvis** and a smaller lower part the **True Pelvis.**

The **True Pelvis** contains the **Bladder, Rectum** and, in the female, the **Uterus** and **Ovaries.** It is bounded in front by the Pubic Bones together forming the **Pubic Arch.** The union of the two Pubic Bones in the middle line is called the **Symphysis Pubis.** On each side of the True Pelvis is the large **Obturator Foramen.** Behind are the deeply hollowed out Sacrum and Coccyx.

The bone of the Thigh is the **Femur,** the longest and the strongest bone in the skeleton.

It consists of—

1st.—The **Shaft,** cylindrical, and presenting behind a rough ridge for the attachment of muscles.

2nd. -The **Upper Extremity** consisting of the rounded articular **Head** which fits into the Acetabulum to form the Hip Joint, the narrower **Neck** which unites the Head to the shaft, and two rough prominences the **Great** and the **Small Trochanter.** The former can be felt under the skin, the latter gives the point of attachment to the Psoas muscle.

3rd.—The **Lower Extremity** which is expanded and presents two prominent articular processes, the **Internal** and the **External Condyle,** one on each side. The Condyles articulate below with the Tibia and in front with the Patella to form the **Knee Joint.**

The **Patella** or Knee Cap or Knee Pan is a small bone into which the **Quadriceps Extensor Tendon** is inserted above and which is attached below by the strong **Ligamentum Patellæ** to the Tibia.

The bones of the **Leg** are the **Tibia** and **Fibula** which articulate together above and below.

The **Tibia** is the inner and stronger and consists of—

1st.—The **Shaft,** the sharp anterior border of which forms the shin.

2nd.—The **Upper Extremity** consisting of two expanded **Tuberosities,** an Internal and an External. Each presents on its upper surface a slightly hollowed articular surface for the corresponding Condyle of the Femur.

In front of the upper part of the Tibia is a rough projection the **Tubercle of the Tibia** to which the Patellar Ligament is attached.

3rd.—The **Lower Extremity** which has on its inferior surface an articular surface for the Astragalus, and projects downwards on the inner side as the **Internal Malleolus.**

The **Fibula,** much thinner than the Tibia, is on the outer side of the Leg. Its lower end projects downwards to form the **External Malleolus.** The two Malleoli with the articular surface on the lower surface of the Tibia enclose a square shaped cavity into which the Astragalus fits to form the **Ankle Joint.**

The bones of the **Ankle** or **Tarsus** are the Seven Tarsal Bones.

Of these the **Os Calcis** forms the Heel and the **Astragalus** forms, with the Tibia and Fibula, the **Ankle Joint.**

The bones of the **Foot** are the Five **Metatarsals** articulated behind with some of the Tarsal Bones and in front with the Phalanges.

The bones of the **Toes** are the **Phalanges** arranged as in the Fingers, and Fourteen in all.

The bones of the Foot are arranged and bound together in the form of an **Arch** more or less marked.

This Arch is kept up by strong ligaments and muscles.

When these ligaments and muscles yield, the arch gives way and **Flat foot** results.

Lecture V.

THE MUSCLES.

All the movements of the Body are produced by the contraction or shortening of the **Muscles.**

The Contraction of a Muscle may be under the control of the Will, when it is called a **Voluntary** muscle, or may occur independently, when it is called an **Involuntary** muscle. The Muscle of the Heart, of the Intestines, Bladder, and other hollow organs, is Involuntary Muscle.

The Voluntary Muscles being attached at each end, their contraction brings closer together the parts to which they are attached. The more fixed attachment is called the **Origin** of the Muscle and the less fixed the **Insertion.** Thus if a muscle be attached at one end to the Trunk and at the other end to a Limb, the former attachment, being more fixed, is called the Origin, and the latter, being less fixed, the Insertion.

Chief Muscles of the Head and Neck.

Face Muscles.—Numerous little muscles are inserted into the skin and produce the many movements of the face, including the eyelids and mouth.

There are also circular muscles surrounding the eyes and the mouth, which by their contraction close these apertures.

All the muscles of the Face are supplied by the Facial Nerve.

Other muscles of the Head and Neck are—

	Origin.	Insertion.	Action.
The **Masseter**	The Malar Bone and Zygoma	The Ramus of the lower jaw	To close the jaw
The **Temporal**	The Temporal Bone	Coronoid Process of Lower Jaw	To close the jaw
The **Sterno-Mastoid**	The Sternum (upper edge) and Clavicle (inner end)	Mastoid Process	To bend the head forward
The **Trapezius**	Occipital Bone and Spines of Vertebræ	Scapula and Clavicle	(1) To lift the shoulder (2) To bend the head to one side

Chief Muscles of the Upper Extremity.

	Origin.	Insertion.	Action.
The **Deltoid** forms the front of the shoulder	The Clavicle and the Acromion Process and Spine of the Scapula	The Humerus	To abduct the shoulder
Pectoralis Major	The Clavicle Sternum and Upper Ribs	The Humerus	To ~~duct~~ adduct and flex the shoulder
The **Biceps** in front of the Arm	The Scapula by 2 heads	Upper end of Radius	(1) To flex the elbow (2) To supinate the hand
The **Triceps** at the back of the Arm	TheHumerus by 3 heads	The Olecranon Process	To extend the elbow

The Muscles of the front and inner side of the Forearm flex, that is bend forwards, the wrist and the fingers.

The muscles of the back and outer side of the Forearm extend, that is bend back, the wrist and the Fingers.

Pronation and Supination of the Hand.

In **Pronation** the Radius crosses the Ulna and the hand is turned so that the palm is backwards.

In **Supination** the bones lie side by side and the palm faces forwards.

Chief Muscles of the Trunk.

	Origin.	Insertion.	Action.
The **Diaphragm**	The Xiphoid Cartilage, the lower ribs and the upper Lumbar Vertebræ	The flat kidney shaped Central Tendon	Its contraction draws down the central tendon and so enlarges the Thoracic Cavity
The **Rectus Abdominis**	The Pubes	The 5th, 6th and 7th ribs	To bend the trunk forwards

Chief Muscles of the Lower Extremity.

	Origin.	Insertion.	Action.
The **Gluteus Maximus** in the buttock	Ilium and Sacrum	The Femur	To extend the hip
The **Psoas**	The Lumbar Vertebræ	Small Trochanter of Femur	To flex the hip
The **Quadriceps Extensor** in front of the thigh	Ilium and Femur	Upper border of Patella and so by the Ligamentum Patellæ to the Tibia	To extend the knee

The muscles of the back of the Thigh are the **Hamstrings.** They flex the Knee and extend the Hip.

The muscles of the Front of the Leg flex the Ankle and extend the Toes.

The muscles of the Calf at the Back of the Leg, extend the Ankle, and flex the Toes.

The chief calf muscle is the **Gastrocnemius** which arises from the lower end of the Femur and is inserted by the Tendo Achillis at the back of the Ankle into the Os Calcis. It extends the ankle.

Lecture VI.

THE JOINTS.

A **Joint** is a union between two or more parts of the skeleton.

Joints are of three kinds.

1.—**Immovable Joints** as the Sutures of the Skull.

2.—**Yielding Joints** which permit of slight movement, as those between the Bodies of the Vertebræ which are bound together by tough fibro-cartilages, which allow only a slight give.

3.—**Movable Joints** which are divided into—

1.—**Gliding Joints** as those between the Sternum and the Clavicles.

2.—**Hinge Joints** as the Elbow, Ankle, Wrist.

3.—**Ball and Socket Joints** as the Hip and Shoulder.

4.—**Pulley Joints** as between the Radius and Ulna.

In the **Movable Joints** the articular surfaces which enter into the joint are covered with a smooth **cartilage.** The bones are held together by tough **ligaments,** which with a membranous covering between them surround the joint forming a usually complete **Capsule.**

This Capsule is lined on its inner surface by a smooth **Synovial Membrane** which secretes a little oily fluid to lubricate the joint.

The **Movements** which take place in joints are—

1.—**Gliding.**

2.—**Flexion,** or bending.

3.—**Extension,** or straightening.

4.—**Adduction,** or movement towards the middle line of the body.

5.—**Abduction,** or movement away from the same line.

6.—**Circumduction,** a combination of the four preceding movements.

7.—**Rotation,** the movement of a bone on its own long axis.

The Principal Joints are—

The **Temporo Maxillary Joint,** a hinge and gliding joint formed by the Condyle of the Lower Jaw below fitting into the Glenoid Fossa of the Temporal Bone above.

The **Shoulder Joint,** a ball and socket joint formed by the Scapula and Humerus.

The **Elbow Joint,** a hinge joint, formed by the Humerus, Radius and Ulna.

The **Wrist Joint,** a double hinge joint formed by the Radius and the first row of Carpal bones.

The **Hip Joint,** a ball and socket joint formed by the Os Innominatum and the Femur. It has a very strong capsule.

The **Ankle Joint,** a hinge joint formed by the Tibia, Fibula, and Astragalus.

The **Knee Joint** is a hinge joint with a little rotatory movement.

The **Bones** which enter into it are—

Above: The Lower End of the Femur, made up chiefly of the two Condyles.

Below:—The two Tuberosities of the Upper End of the Tibia, and

In Front:—The Patella, which moves up and down on the Femur as the joint is flexed or extended.

The Femur and Tibia are bound together on three surfaces by strong **Ligaments.** These are the **Posterior, External** and **Internal** Ligaments.

In Front the joint is closed in by the Patella, by the Quadriceps Extensor Tendon, which is attached to its upper edge, and by the Ligamentum Patellæ, which passes downwards from its lower edge.

A membranous covering fills in the gaps between the ligaments and tendons and so a complete **Capsule** is formed, lined by a **Synovial Membrane.**

Between the Femur and the Tibia there are two thin plates of cartilage, the **Semilunar Cartilages.**

The **Movements** which occur in the knee are **Flexion, Extension,** and a small amount of **Rotation.**

The chief **Muscles** which flex the knee are the **Hamstrings.**

The chief Muscle which extends the knee is the **Quadriceps Extensor.**

(For detailed account of the parts of the Bones which enter into the above joints, see the Lectures on the Bones.)

Lecture VII.

CIRCULATORY SYSTEM.

The fluid Blood circulates through a system of tubes called Blood Vessels which run through every part of the human body.

This movement of the blood is brought about by the pumping action of the **Heart** produced by the contraction of its muscular fibres.

The Heart contracts in the Adult about 72 times a minute, each contraction being followed by a relaxation.

From the Heart the blood is driven into the **Arteries** in which the pressure is consequently high and the walls therefore are thick and tough. They are also **elastic,** that is capable of stretching.

The wall of an artery contains three coats—

1st.—An outer **Fibrous Coat.**

2nd.—A middle **Muscular Coat** in which the fibres encircle the tube just as the hoops encircle a barrel.

3rd.—An inner **Elastic Coat** with a smooth **Epithelial lining.**

When the muscular coat contracts the size of the artery is lessened. When it relaxes the size is increased. The elastic tissue present allows of this alteration of size.

The beat of the Heart produces in the Arteries a pulsation which can be felt as the **Pulse** in those nearer the surface.

The blood is driven forcibly along the arteries from the heart by each beat and there is thus no tendency for it to flow backwards.

The Arteries divide and subdivide into smaller and smaller arteries, the smallest being called **Arterioles** and these at last open into a meshwork of very minute vessels called **Capillaries.** The walls of the **Capillaries** are exceedingly thin and allow of the passage of fluid from the blood into the tissues around and from the tissues into the blood.

From the meshwork of capillaries the blood passes into larger vessels called **Venules,** and these unite together to form still larger vessels the **Veins.**

The pressure in the Veins is very small and they are consequently thinner walled than the Arteries and collapse when they are empty of blood. They have the same coats as the arteries.

The veins unite together to form larger and larger veins until finally all the blood passes into very large Veins which open into the Heart.

The flow of the Blood in the Veins is towards the Heart and is slow, the force of the Heart's beat having been much reduced by the passage of the blood through the capillaries. Hence there is some tendency for the blood to flow backwards especially when its direction is upwards as in the extremities in the upright position. To prevent the possibility of this backward flow many Veins are provided with **Valves** which only allow the blood to flow onwards.

Thus in the Arteries the blood is flowing **from** the Heart and the pressure is **high.** In the Veins the flow is **towards** the Heart and the pressure is **low.**

THE HEART.

The Heart is a muscular bag situated in the Thorax towards its lower part, and between the two lungs.

The average length of the adult Heart is 5 inches, and the average weight 10 ounces. The size of the Heart of any individual is, roughly, that of the closed fist of the same individual.

The Heart is obliquely placed, the rounded lower end called the **Apex** pointing downwards and to the left and being in contact with the **Diaphragm.** The broader upper end is called the **Base.** The Heart is thus shaped something like a cone.

It is enclosed in a membranous bag called the **Pericardium,** the inner surface of which is smooth and shiny. This smooth layer is reflected over the heart itself, and there is always a small amount of watery or serous fluid in the Pericardial Sac. The movement of the Heart which occurs with its contraction thus takes place without friction. (A smooth lining membrane, such as the Pericardium, which secretes a thin watery fluid, is called a **Serous Membrane.** The **Pleuræ** covering the Lungs, and the **Peritoneum** covering the abdominal organs, are other examples.)

The contraction of the Apex of the Heart, produces a pulsation which can be often seen and felt. This is called the **Apex Beat,** and its usual position is in the fifth left Intercostal Space about one inch internal to the nipple line.

The Heart contains four Chambers, the **Right** and **Left Auricles** and the **Right** and **Left Ventricles.** Of these the

Auricles are much thinner walled than the Ventricles and are placed above them. Each Auricle opens into the corresponding Ventricle, there being no communication between the two sides of the Heart. The Right Ventricle is much thinner walled than the Left.

The great Veins which carry the blood to the Heart open into the Auricles. Two Veins, the **Superior Vena Cava** and the **Inferior Vena Cava,** open into the Right Auricle, and four Veins, the four **Pulmonary Veins,** open into the Left Auricle. By the contraction of the Auricles the blood is driven from them into the Ventricles. By the contraction of the Ventricles it is driven on into the great Arteries. One Artery opens out of each Ventricle, namely the **Aorta** from the Left Ventricle, and the **Pulmonary Artery** from the Right Ventricle.

Valves are placed between the Auricles and Ventricles and also at the openings of the great Arteries, so as to ensure that the flow of blood through the Heart shall only occur in one direction.

The Valve between the Right Auricle and the Right Ventricle, which only allows the blood to flow from Auricle to Ventricle, is called the **Tricuspid Valve.** It has three **Cusps** or flaps. The corresponding one, between the Left Auricle and the Left Ventricle, is called the **Mitral Valve.** It has two Cusps.

The Valves at the openings of the Aorta and the Pulmonary Artery are called **Semilunar Valves.** They have each three Cusps, and they only allow the blood to pass along the arteries from the Heart.

Inflammation of the Valves leads to contraction of the flaps, which is the condition usually present in Heart Disease.

Lecture VIII.

CIRCULATORY SYSTEM (continued).

CIRCULATION OF THE BLOOD.

The Blood from the **Right Ventricle** passes into the **Pulmonary Artery,** and so to the **Lungs.** The blood from the **Left Ventricle** passes into the **Aorta,** and so to the **rest of the body.**

From the **Lungs** the blood returns by the four **Pulmonary Veins** to the **Left Auricle.** From all the rest of the body it returns by the great veins, the **Superior** and **Inferior Venæ Cavæ** to the **Right Auricle.**

There are thus two great Circulatory Systems, the **Pulmonary** and the **Systemic.**

From the Right Auricle the blood passes into the Right Ventricle. From the Right Ventricle it passes to the Lungs, whence it returns to the Left Auricle, thus completing the Pulmonary Circulation.

From the Left Auricle the blood passes to the Left Ventricle. From the Left Ventricle it passes to the whole of the body with the exception of the Lungs, and returns thence to the Right Auricle, thus completing the Systemic Circulation.

PULMONARY CIRCULATION.

The Blood leaves the Right Ventricle by the Pulmonary Artery, which divides into two branches, the **Right** and **Left Pulmonary Arteries,** one to each Lung.

These sub-divide and carry the blood to the system of Capillaries in the Lungs, from which it is returned by the **Pulmonary Veins,** two from each Lung. These four Pulmonary Veins open into the Left Auricle.

SYSTEMIC CIRCULATION.

The whole of the Blood for this Circulatory System leaves the Left Ventricle by the **Aorta,** which passes upwards and then forms an **Arch** across the upper part of the Thorax.

The branches of the **Arch of the Aorta** are—
The **Innominate Artery;**
The **Left Carotid Artery;** and
The **Left Subclavian Artery.**

The Innominate Artery divides into the **Right Carotid** and the **Right Subclavian Arteries.**

The two Carotid and the two Subclavian Arteries supply the Head, Neck and Upper Extremities with blood.

Arteries of the Head and Neck.

The two Carotid Arteries run upwards on each side of the Neck and each divides opposite the Thyroid Cartilage into the **External and Internal Carotid Arteries.**

Of these the **Internal Carotid Artery** passes into the Cranium through a bony Canal and supplies the Brain with blood.

The **External Carotid Artery** is so called because it supplies the parts outside the Cranial Cavity. It also supplies in part the tissues of the neck, and gives many branches, included among which are—

(1) The **Lingual Artery,** which supplies blood to the Tongue.
(2) The **Facial Artery,** which supplies blood to the Face.
(3) The **Temporal Artery,** which supplies blood to the Anterior part of the Scalp and can be felt pulsating just in front of the ear.

The **Subclavian Artery** circles outwards over the apex of the Lung, and then lies on the upper surface of the First Rib, where its pulsation can be felt and against which it can be compressed. It gives branches which supply part of the **Neck** with blood.

Arteries of the Upper Extremity.

At the outer border of the First Rib the **Subclavian Artery** becomes the **Axillary Artery,** the main trunk for the Upper Extremity.

The **Axillary Artery** runs downwards through the **Axilla** or armpit and becomes the **Brachial Artery** at its lower border.

The **Brachial Artery** situated at first on the inner side of the Arm, gradually turns forwards until at the bend of the Elbow it lies in front and there it divides into the **Radial** and **Ulnar Arteries.**

These run downwards through the Forearm, between the superficial and deep muscles, to reach the Hand, the Radial being on the outer side and the Ulnar on the inner.

On the outer side of the Wrist the Radial Artery can be felt as the Pulse. The Ulnar Artery is felt with more difficulty on the inner side.

In the Palm they together form two Arterial Arches called the **Palmar Arches.** On the back of the wrist branches from them form a third Arch.

From these three arches the **Digital Arteries** are given off which run along the sides of the Fingers and supply them with blood.

From all these arteries many branches are given off which supply with blood the different tissues of the extremity.

The Muscles requires most blood supply, but the Bones, Fat, Skin, Joints, etc., all receive their share.

Veins of the Head and Neck.

The Blood returning from the Brain runs along very large channels inside the skull which are called **Sinuses.** The largest of these are situated on the inner surface of the bones in well marked grooves.

The greater part of the blood passes out through a large foramen into the **Internal Jugular Vein,** a very large vein which runs down the neck accompanying the Carotid Arteries. It finally unites with the **Subclavian Vein** which returns the blood from the Upper Extremity.

The **External Jugular Vein** is a superficial vein which can be seen in the neck and which opens into the Subclavian Vein.

Veins of the Upper Extremity.

The blood returns from the Hand and Forearm by **Superficial Veins** which can be seen under the skin and by **Deep Veins** which run with the Radial, Ulnar, and Brachial Arteries and are called **Venæ Comites.**

A superficial vein called the **Median Basilic Vein** which lies towards the inner side of the Elbow is the one usually chosen for the operation of Bleeding or **Venesection.**

The Venæ Comites of the Brachial Artery unite to form the **Axillary Vein** at the lower border of the Axilla.

This runs upwards with the Axillary Artery and becomes the **Subclavian Vein** at the outer border of the First Rib.

The Subclavian Vein on each side unites with the **Internal Jugular Vein** to form the **Innominate Vein** and the two Innominate Veins unite together to form the **Superior Vena Cava** which opens into the Right Auricle.

Lecture IX.

CIRCULATORY SYSTEM (continued).

Arteries of the Thorax.

The Aorta after forming its Arch turns downwards and runs, under the name of the **Thoracic Aorta** through the Thorax, being situated in front of the bodies of the Dorsal Vertebræ. It then passes through the Diaphragm and enters the Abdomen, where it is called the **Abdominal Aorta.**

The most important branches of the Thoracic Aorta are the **Intercostal Arteries** which run outwards between the Ribs, one to each Intercostal Space.

Arteries of the Abdomen.

The Abdominal Aorta begins at the opening in the Diaphragm and runs downwards in front of the bodies of the Lumbar Vertebræ.

The chief branches of the Abdominal Aorta are—

1.—The **Cœliac Axis** which divides into three branches
   The **Gastric Artery** to the Stomach;
   The **Hepatic Artery** to the Liver; and
   The **Splenic Artery** to the Spleen.
2.—The **Superior Mesenteric Artery** which supplies the Small Intestine and part of the Large Intestine with blood.
3.—The **Inferior Mesenteric Artery** which supplies the remainder of the Large Intestines as far down as the Rectum.
4.—The **Renal Arteries** one to each Kidney.

The Abdominal Aorta divides, at a point nearly corresponding with the Umbilicus into the two **Common Iliac Arteries.** Each Common Iliac Artery divides into the **Internal** and the **External Iliac Arteries.**

Of these the **Internal Iliac Artery** gives branches which supply the different organs in the Pelvis, especially the Bladder and, in the Female, the Uterus.

The **External Iliac Artery** runs downwards, and behind Poupart's Ligament becomes the **Femoral Artery,** the main Artery of the Lower Extremity.

Poupart's Ligament is a strong fibrous band which is placed obliquely in the fold of the Groin passing from the Anterior Superior Spine of the Ilium to the Pubes.

Arteries of the Lower Extremity.

The **Femoral Artery** passes beneath Poupart's Ligament at a point midway between the Anterior Superior Spine of the Ilium and the Symphysis Pubis. Here it is placed in front of the Brim of the Pelvis against which it can be compressed. It then passes down the Thigh inclining to the inner side, and winding round the Femur reaches the back where it enters the space situated behind the Knee which is called the **Popliteal Space**, or Ham. Here it becomes the **Popliteal Artery.**

The **Popliteal Artery** passes downward behind the knee through the Popliteal Space and at the lower part of the space divides into the **Anterior** and **Posterior Tibial Arteries.**

The **Anterior Tibial Artery** passes forwards between the Tibia and Fibula and then runs down the front of the Leg situated deeply beneath the muscles. Reaching the Ankle it becomes the **Dorsalis Pedis Artery,** the pulsation of which can be felt on the dorsum of the Foot. It gives branches which supply **Digital Arteries** to the toes.

The **Posterior Tibial Artery** passes deeply down the back of the Calf and winds underneath the Internal Malleolus to reach the sole of the Foot. Here it divides and its branches supply all the tissues of the sole, and also give **Digital Arteries** to the toes.

As in the Upper Extremity all the arteries of the Lower Extremity give off many branches to the muscles, joints, bones, skin, etc., of the limb.

Veins of the Lower Extremity.

There are two definite **Superficial** Veins the **External** and the **Internal Saphenous Veins.**

Of these the **External Saphenous Vein** runs up the back of the calf.

The **Internal Saphenous Vein** runs up from the foot through the leg and thigh situated on the inner and front part of the limb and opens a little below Poupart's Ligament into the Femoral Vein.

Venæ Comites accompany the Anterior and Posterior Tibial Arteries and unite to form the **Popliteal Vein** which runs with the Popliteal Artery and becomes the **Femoral Vein** at the upper part of the Popliteal Space. The Femoral

Vein runs with the Femoral Artery and becomes the **External Iliac Vein** behind Poupart's Ligament.

Veins of the Abdomen.

The Veins from the Pelvic organs including a small part of the Rectum join together to form the **Internal Iliac Vein** which unites with the **External Iliac Vein,** returning blood from the Lower Extremity, to form the **Common Iliac Vein.**

The Two Common Iliac Veins unite together to form the **Inferior Vena Cava** which runs upwards and finally passes through the Diaphragm and opens into the Right Auricle.

The **Renal Veins** returning blood from the Kidneys and the **Hepatic Veins** returning blood from the Liver, open into the Inferior Vena Cava.

Portal System.

The **Splenic Vein** returning blood from the Spleen, the **Superior** and **Inferior Mesenteric Veins** returning blood from the Large and Small Intestines and the **Gastric Vein** returning blood from the Stomach all unite into one large vein called the **Portal Vein.**

This system of Veins is called the **Portal System.**

The Portal Vein does not open directly into the Vena Cava but unlike every other vein in the body, enters the Liver and breaks up into Capillaries which finally re-unite forming veins, which open into the Hepatic Veins, which in turn open into the Inferior Vena Cava.

Thus the blood in the Portal System passes through two sets of capillaries. First; in the Spleen, Stomach, Intestines, etc., and Secondly; in the Liver.

Veins of the Thorax.

The **Intercostal Veins** run with the Intercostal Arteries.

Lecture X.

CIRCULATORY SYSTEM (continued).

THE BLOOD.

Blood consists of—

1st.—A clear fluid, the **Blood Plasma** or **Liquor Sanguinis.**

2nd.—The **Corpuscles,** white and red, which float in the Plasma.

Blood Plasma is a clear alkaline fluid consisting mainly of

Water,
Salts, and
Two Proteins, **Blood Albumen** and **Fibrinogen.**

The **Corpuscles** are of two kinds, **White** and **Red,** there being about 500 red to 1 white corpuscle.

The **Red Corpuscles** are circular plates, concave on both sides. A single corpuscle under the microscope is yellow, but a mass of them looks red and they give to the blood its colour.

The colour of red corpuscles is due to a substance which they contain called **Hæmoglobin.**

The **White Corpuscles** vary in shape and size, and each one also varies in shape from time to time. They are able to pass through the walls of the capillaries and then move through the tissues. They can also attack and destroy micro-organisms which have invaded the body.

Functions of the Blood.

The Blood circulates by way of the Blood Vessels through every part of the human body and performs the following functions :—

1st.—It receives the **nutrient material** absorbed from the Intestinal Canal and carries it to all the Organs, supplying them with what they need. Thus material is carried to the Muscles for their

contraction, to the Glands for the manufacture of their secretions, and to all the Tissues for their growth, and to replace any loss.

2nd.—The Blood receives from the different organs and tissues **Waste Materials,** and carries them to the Excretory Glands by which they are separated and expelled.

3rd.—The blood takes up **Oxygen** in the Lungs and carries it to all parts of the body. It does this by means of the Hæmoglobin in the red blood corpuscles. This substance very readily takes up Oxygen and as readily gives it up again. When it is combined with Oxygen it is bright red; when it has given up Oxygen it becomes purple or purple black.

4th.—The Blood distributes **Heat,** especially to the skin, thus maintaining and equalising the temperature of the body.

5th.—The Blood provides the body with **Moisture.**

Arterial and Venous Blood.

The blood in the Arteries, having been charged with Oxygen in the Lungs, is bright red in colour. Such blood is called **Arterial Blood.**

The only exception to this is the blood in the Pulmonary Artery, which is returning from the Systemic Capillaries to the Lungs, and is dark or "Venous."

The blood in the Veins having lost its oxygen in the Capillaries, is dark in colour, either purple or purple black. Such blood is called **Venous Blood.**

The only exception to this is the blood in the Pulmonary Veins, which is returning from the Lungs, where it has taken up oxygen, and is therefore bright red or "Arterial."

Coagulation.

When Blood is drawn off and allowed to stand, it **clots.** At first a jelly is formed, but after a time this separates into a yellow fluid, the **Blood Serum,** and a red solid clot floating in it.

Clotting or Coagulation is due to the conversion of the soluble **Fibrinogen** into solid **Fibrin** which comes down and encloses the corpuscles in its meshes.

Blood Clot therefore consists of—

Fibrin.
Red and **White Corpuscles.**

While **Blood Serum** consists of—

Water.
Salts.
Albumen.

The clotting of blood is **prevented** by the walls of healthy blood vessels.

On the other hand, disease or injury of a blood vessel is very frequently followed by coagulation of the blood within it.

In the disease called Hæmophilia the blood lacks, more or less completely, the power of coagulating.

The clotting of blood which has been withdrawn from the body is **retarded** by cold (40° F. or lower) and by the addition of certain salts, such as common salt, magnesium sulphate, sodium citrate, etc.

Of these sodium citrate is used in the operation of transfusion of blood. A solution of sodium citrate is added to the blood drawn from the donor, to prevent it from clotting before it can be injected into the veins of the recipient.

The clotting of drawn blood is **hastened** by rest, by exposure to the air and by contact with foreign bodies.

Lecture XI.

DIGESTIVE SYSTEM.

FOOD.

The human body is continually giving off heat, and, even when at rest, performing work, and it does so as the result of the slow combustion or burning of food substances.

Food is thus to the human body what fuel is to a steam engine; and the main changes which occur are the same in both, namely, a combination of Carbon and Hydrogen with Oxygen to form Carbon Dioxide and Water respectively.

In the human body however this combustion occurs much more slowly and less violently than in a steam engine.

As fresh fuel has to be continually supplied to an engine, so fresh food has to be continually supplied to the human body, as it is being constantly used up to produce heat and movement.

Food substances are of two kinds: (1) **Organic** and (2) **Inorganic.**

Organic Food consists of materials which have already formed part of a living organism, either animal or vegetable.

There are three varieties of Organic Food :—

I.—**Proteins** or **Nitrogenous Foods,** which are composed chiefly of Carbon, Hydrogen, Oxygen and Nitrogen.

They are of two kinds :—

1.—**Animal Proteins** such as—

Albumen in white of egg and in blood.
Myosin in muscle.
Caseinogen in milk, which becomes **Casein** when the milk curdles.
Fibrinogen in blood.

2.—**Vegetable Proteins**—

Gluten in flour.
Legumen in vegetables.

II.—**Carbohydrates** which are composed of Carbon, Hydrogen and Oxygen, the Hydrogen and Oxygen being in the same proportion as they are in Water, namely, two atoms of Hydrogen to one of Oxygen.

The Carbohydrates are—

1.—**Starch.**

2.—**Sugar** in different forms, Cane, Grape, Beet and Milk Sugar.

III.—**Fats,** which are composed of Carbon, Hydrogen and Oxygen, the Hydrogen and Oxygen being not in the same proportion as in water.

Inorganic or **Mineral Food** consists of water and certain salts of which common salt is the most important.

These are contained in many of the organic foodstuffs. In addition water and common salt are frequently taken separately.

In order to maintain healthy life the diet must contain:—

1.—**Inorganic Food,** viz. water and salts.

2.—**Organic Food** in its three varieties, Proteins, Carbohydrates and Fats.

3.—Small quantities of certain essential substances, the **Vitamines** described below.

Vitamines.

A number of fresh organic foodstuffs have been found to contain small quantities of certain active vital substances which are essential to the growth and well-being of the body.

These substances are called **Vitamines.**

There are three varieties of Vitamines, and if the body does not receive a regular supply of all three, growth fails and disease develops.

The three varieties are :—

I.—**Fat-Soluble-A-Vitamine.** This is present in animal fats, especially in Cod Liver Oil, and also in milk, butter and eggs. It is not present in vegetable oils and therefore margarine, when made entirely from nut oil, is not a satisfactory article of diet.

Lack of the Fat Soluble Vitamine leads to Rickets and impaired growth.

II.—**Water-Soluble-B-Vitamine.** This is present in the germ of seeds, in some fresh vegetables and in eggs. Lack of it leads to neuritis, wasting and impaired growth.

III.—**Water-Soluble-C-Vitamine.** This is especially present in certain fruits such as lemons, oranges and limes. Lack of it leads to Scurvy and impaired growth.

Vitamines are readily destroyed by great or prolonged heat and by other factors.

Thus twice boiled milk, twice cooked meat, bacon and tinned meat, contain little or no vitamines, those originally present having been destroyed by the process to which the food has been submitted.

Lecture XII.

DIGESTIVE SYSTEM (continued).

ALIMENTARY CANAL.

The **Alimentary Canal** or **Tract,** is a tube extending through the body from the mouth to the anus.

It is lined internally throughout its length by a soft mucous membrane, containing glands which secrete a glairy fluid called mucus. This fluid moistens and lubricates the surface.

The Alimentary Canal is made up of the following parts, continuous with one another :—

The Mouth.
The Pharynx.
The Œsophagus.
The Stomach.
The Small Intestine.
The Large Intestine.

The Mouth and Pharynx.

The **Mouth** is a cavity opening in front to the exterior by an aperture which can be opened or closed by muscular action.

The roof of the mouth is formed in front by the **Hard Palate** and behind by the **Soft Palate.** Its floor is formed mainly by the **tongue.** On each side it is bounded by the **cheeks** Behind, the mouth opens through an aperture called the **Fauces** into another cavity, the **Pharynx.** The **teeth** of the upper and lower jaws are placed in front and at the sides of the mouth.

The **Fauces,** the opening between the mouth and the pharynx, have the **Tonsils,** one on each side.

The **Uvula** hangs down from the posterior edge of the soft palate into the opening of the fauces.

The **Pharynx** is a cavity situated behind the mouth out of which it opens.

The upper part of the pharynx is called the **Naso-Pharynx.** The two **nasal cavities** open into this by openings which are called the Posterior Nares.

Two tubes open out of the Pharynx below. In front is the opening of the **Larynx** which is called the **Glottis.** Behind is the opening of the **Œsophagus** or **Gullet.**

The mouth and pharynx are lined by a **mucous membrane** which is continuous with that lining the remainder of the Alimentary Tract, and at the Lips merges into the Skin.

Outside this mucous membrane are the muscles which are concerned in the movements of the food in mastication and swallowing.

The **Teeth** vary in shape. Those in front, the **Incisors** and **Canines** are sharp for cutting purposes. The back teeth, the **Bicuspids** and **Molars** are, on the other hand, flat for purposes of grinding.

Each tooth is made up of a **Crown,** above the gum, a **Neck,** in the gum, and a **Root** embedded in the jaw. The root has one, two or three Fangs.

A Tooth consists chiefly of a hard material called **Dentine.** The Crown is covered by a thin layer of a very hard smooth material called **Enamel.**

In the centre of each tooth is a cavity called the **Pulp Cavity** which contains blood vessels and nerves.

The Œsophagus or Gullet.

The **Œsophagus** is a tube about 9 inches in length. Its upper end opens out of the lower part of the **Pharynx,** the opening being situated behind that of the Larynx.

It then passes downwards through the **neck** and **thorax** being situated in front of the vertebræ and finally passes through the **Diaphragm** and opens at once into the **Stomach.**

The Œsophagus is lined with a mucous membrane, outside which is a muscular coat.

The Stomach.

The **Stomach** is a bag situated in the upper part of the abdomen towards the left side. It is lined internally by a mucous membrane which contains mucous glands and also the gastric glands which secrete the **Gastric Juice.** Outside the mucous membrane is a muscular coat, with fibres running in all directions. Externally the stomach is covered by the smooth **Peritoneum** the **serous membrane** which lines the whole of the abdominal cavity and its contents.

The œsophagus opens into the stomach in its upper part and towards its left extremity, the opening being called the **cardiac orifice.**

The Duodenum, the first part of the Small Intestine, opens out of the Stomach at its right extremity, the opening being called the **Pylorus.**

Both the Cardiac Orifice and the Pylorus are surrounded by circular muscles by the contraction of which they can be closed.

The Small Intestine.

The Small Intestine is a tube about 20 feet in length, which is arranged in coils in the abdomen and occupies the greater part of that cavity.

It is divided into three parts as follows—

The **Duodenum** is the first part and is about 10 inches long.

The second part is called the **Jejunum** and the third part the **Ileum.** There is no sharp boundary between these two but about two-fifths is considered Jejunum and the remaining three-fifths Ileum.

The Ileum at its lower extremity opens into the Large Intestine.

The Small Intestine is lined internally with a mucous membrane.

To increase its surface the mucous membrane is thrown into folds called **Valvulæ Conniventes,** and has also many minute projections called **Villi.** The latter set closely together give it a surface like velvet.

It also contains many glands. Of these some secrete mucus and others a fluid called the **Succus Entericus** or Intestinal juice.

In addition it contains large oval collections of lymphatic tissue which are called **Peyer's Patches.** These are situated in the lower part of the small intestine.

Outside the mucous membrane is a muscular coat with fibres running both round the tube and also along its length.

Externally the small intestine is covered with smooth Peritoneum.

The Large Intestine.

The **Large Intestine** is about 5 feet in length. It is a larger tube than the Small Intestine and consists of the following parts—

I.—The **Cæcum** situated in the Right Iliac Fossa with the **Vermiform Appendix** attached. The latter is a small tube about the size of a pen. It varies in length from 1 to 6 inches. It opens out of the Cæcum at one end, the other end being blind.

II.—The **Ascending Colon.**
III.—The **Transverse Colon.**
IV.—The **Descending Colon.**
V.—The **Iliac Colon.**
VI.—The **Pelvic Colon.**
VII.—The **Rectum** which opens to the exterior at the **Anus,** the opening being surrounded by a circular muscle, the **Sphincter Ani.**

The Large Intestine has a structure similar to that of the Stomach and Small Intestine.

It is lined internally by a mucous membrane.

Outside this is a muscular layer with fibres running both round the tube and also along its length.

In the case of the large intestine the longitudinal fibres are arranged in visible bands, which give the tube a tucked or sacculated appearance.

Outside the muscular layer is a covering of Smooth Peritoneum.

Lecture XIII.

DIGESTIVE SYSTEM (continued).

DIGESTION.

The three organic food substances, Proteins, Carbohydrates and Fats have to be altered and made soluble before they can be absorbed, and this process is called **Digestion.**

It is effected by the action upon them of the fluids produced by certain glands, the **Digestive Glands.**

Glands are organs which either manufacture substances from the blood, which are of further use to the body ; or separate waste materials from the blood, which are then got rid of from the body.

The former are called **secretory** glands, and the latter **excretory.**

A typical gland consists of a number of cells, which, on one side, are in contact with blood vessels, and on the other side with a passage or duct.

The cells secrete or excrete materials from the blood, and turn them into the duct.

The Digestive Glands are secretory glands and the action of the fluids they secrete upon food, is due to the presence in these fluids of certain substances called **ferments.**

A **ferment** is a substance which is capable of transforming one substance into another and of continuing to do so without being itself changed.

The conversion of starch into sugar is an example of the change which a certain ferment is capable of producing.

Digestion in the Mouth.

On entering the body food is first taken into the mouth, where the following processes occur :—

1st.—The food is **masticated** by the teeth, that is to say, it is divided and broken up. The incisors and canines exercise a cutting action and the molars a grinding action.

The process of mastication is of great importance in preparing the food for the gastric juice, and hence the dyspepsia which results from deficient teeth or insufficient mastication.

2nd.—The food is mixed with and acted upon by the **Saliva** a fluid secreted by the Salivary Glands.

The Salivary glands are the **Parotid**, the **Sublingual** and the **Submaxillary** Glands. The Parotid glands are situated in front of the ears, and their ducts open into the mouth on the inner surfaces of the cheeks. The Submaxillary Glands are situated below the lower jaw and their ducts open beneath the tongue.

The Saliva is an alkaline fluid which is mixed with the food in the process of mastication and acts upon it in the following ways :—

(1) It moistens and lubricates it, thus helping mastication and swallowing.
(2) It dissolves any soluble material and thus assists the sense of taste.
(3) It converts part of the starch into sugar by means of a ferment called **Ptyalin,** which it contains.

A number of **mucous glands** in the mouth secrete mucus, which is mixed with the saliva and assists its lubricating action.

The masticated food is formed into a Bolus by the action of the muscles of the cheeks and tongue, and this is carried backwards into the Pharynx.

The Pharynx has muscular walls which grasp the bolus of food and pass it downwards into the Œsophagus, the tube which opens out of the Pharynx at its lower and back part.

Gastric Digestion.

The food is passed into the Œsophagus by the contraction of the muscular walls of the Pharynx in the act of swallowing.

It is then driven down the œsophagus by the contraction of its muscular fibres and passes into the stomach through the cardiac opening.

In the stomach it is acted upon by the **Gastric Juice,** the secretion of Glands situated in the mucous membrane with duct openings upon the surface.

The secretion of Gastric Juice is not going on continually, but is excited by the presence of food in the stomach or even in the mouth.

It is a strongly **acid** fluid and is composed mainly of the following substances :—

(1) **Water.**
(2) **Salts.**
(3) **Hydrochloric Acid.**
(4) Two **Ferments, Pepsin** and **Rennet.**

The Gastric Juice is intimately mixed with the food as the result of the churning action set up by the contraction of the muscular fibres of the Stomach, and acts upon it in the following ways :—

I.—Being acid it stops the digestion of starch by Ptyalin.
II.—It converts **Proteins** into soluble **Peptones.** This is effected by the Pepsin. Some proteins are converted into peptones much more quickly than others.
III.—It curdles **milk** by the action of Rennet.
IV.—It dissolves the protein envelope of **Fat,** and so lets it loose.
V.—It exercises an antiseptic action through the Hydrochloric Acid which it contains.

As the result of the action of the Gastric Juice, the food is converted into a thick acid fluid called **chyme** which consists of—

I.—**Sugar** produced by the action of Ptyalin upon Starch.
II.—**Unconverted Starch.**
III.—**Other Carbohydrates.**
IV.—**Peptones** produced by the action of Pepsin upon Proteins.
V.—**Unconverted Proteins.**
VI.—**Fat** let loose from its envelope.
VII.—**Milk** in a curdled state.
VIII.—**Mucus.**
IX.—**Indigestible substances.** And
X.—**Water** and **Salts.**

From the Stomach the Chyme is forced into the Duodenum, but the Pylorus does not relax and allow it to pass until digestion has proceeded to a certain stage.

Intestinal Digestion.

The **Chyme** is driven through the Pylorus, and then is slowly passed along the Intestine by the contraction of its muscular walls. This contraction proceeds in waves and such contraction is called **Peristalsis.**

In the Duodenum the Chyme comes into contact with, and is acted upon by, two digestive fluids ; namely, the **Pancreatic Juice,** and the **Bile.**

The **Pancreatic Juice** is the secretion of the **Pancreas,** a large gland situated behind the Stomach in the loop formed by the Duodenum.

Its secretion passes along a duct and flows into the Duodenum through an opening which is usually common to it and to the Bile Duct by which the Bile is conveyed to the Intestine.

The Pancreatic Juice is alkaline and it acts on the Chyme in the following ways :—

1st.—It converts **Proteins** into **Peptones** by means of a ferment called **Trypsin.**

2nd.—It converts **Starch** into **Sugar** by a second ferment.

3rd.—It emulsifies **Fats** by means of a third ferment.

4th.—Being alkaline it **neutralizes** the acid of the Gastric Juice.

(A second function of the Pancreas is described in Lecture XVI.,

The **Bile** is the secretion of the Liver, a large gland which is described in Lecture XVI.

The Bile acts as follows :—

1st.—It helps in the emulsification of **Fats.**

2nd.—It stimulates the **contraction** of the Intestine and thus acts as a natural purgative.

3rd.—It is slightly **antiseptic,** and so retards the decomposition of the intestinal contents.

4th.—It helps to **neutralize** the Gastric Juice.

5th.—It contains **pigments** which colour the contents of the Intestine.

The emulsification of the fat in the Chyme gives it a milky appearance and thenceforward it is called **Chyle.**

The Chyle passes along the whole length of the Small Intestine, much of it being absorbed during its passage.

The only action of the **Succus Entericus** upon it, is to convert the Sugar into Grape Sugar.

Lecture XIV.

ABSORPTION OF FOOD.

One great function of the Intestinal Canal is the **Digestion** of food, by which the food substances, as stated above are converted into Peptones, emulsified Fats, and Dextrose, and so become in a fit state to be absorbed.

The other great function is the **Absorption** into the body of these substances, together with water and salts.

This is brought about by the passage of the digested food from the Intestinal Canal through the cells of the mucous membrane into blood vessels or lymphatics, and occurs as follows :—

Peptones and **Dextrose** pass through the cells of the mucous membrane of the Intestine directly into the blood stream in the minute capillaries under the mucous membrane. Valvulæ Conniventes and Villi increase the absorbing surface.

The blood vessels all open into the **Portal Vein,** through which the blood flows to the Liver.

The excess of Dextrose which passes into the Liver after a meal containing Carbohydrates, is stored there as **Glycogen**, which is again converted into sugar, and passed into the blood stream as required.

The Pancreas, as described in Lecture XVI., exercises a very important influence over this process.

Emulsified Fats pass through special cells of the mucous membrane, and especially of the Villi, into Lymphatic Vessels placed beneath the cells.

After a meal containing fat, the contents of these vessels have a milky appearance and they are, on that account, called **Lacteals.**

They unite together to open into the **Thoracic Duct,** which opens into the great veins at the root of the neck. The fat thus reaches the blood stream and circulates in it.

Water and **Salts** are absorbed throughout the whole length of the Intestinal Canal. Not only has the water which is swallowed to be absorbed, but also the water of the Saliva, Gastric Juice, and other digestive fluids.

Absorption occurs chiefly in the **Small Intestine,** to a much less degree in the **Large Intestine** and to a still less degree in the **Stomach,** where water and a small amount of sugar and salts only are absorbed.

In the Large Intestine water is chiefly absorbed, and the contents, as they pass along, become more and more dry until finally an undigested and indigestible residue is expelled as Fæces.

Rectal Feeding.

It has been found that certain food substances can be absorbed from the Rectum and Sigmoid Flexure and on this fact is based the process of **Rectal Feeding.**

The substances which can be absorbed are :—

I.—**Proteins,** e.g., Albumen in raw white of egg and raw meat.

II.—**Peptones** such as those present in peptonised milk.

III.—**Carbohydrates.** Raw starch is absorbed. Sugar is also, but is liable to set up irritation.

IV.—**Water, Salts** and **Alcohol** are all readily absorbed.

A **Normal Saline Solution** is particularly well absorbed, and the slow injection of such a solution into the Rectum is one of the most valuable methods of supplying fluid to a patient.

Fats are absorbed very slowly indeed. Thus the yolk of egg which contains much fat is not suitable for rectal feeding.

LYMPHATIC SYSTEM.

The digested Food, after it has entered the blood, is carried to all parts of the human body, and every organ is supplied with what it needs ; either for its growth or to replace what has been used up in carrying out its function.

There is therefore a constant passage of fluid nutrient material from the minute blood vessels into the tissues. All the excess of this fluid, which is called **Lymph,** enters minute vessels called **Lymphatic Vessels** which resemble blood vessels but have much thinner walls.

The Lymphatic Vessels of the Small Intestine perform the special duty of carrying emulsified fats from the intestine towards the blood stream.

Lymphatic Vessels join and rejoin like Veins and run through glands called **Lymphatic Glands.**

A group of these in the neck receives the Lymphatics from the Head and Neck.

Another group in the **Axilla** receives those from the Upper Extremity and a third group in the **Groin** receives the Lymph from the Lower Extremity.

From these Glands larger vessels pass and unite into two **Main Lymphatic Vessels** of which the left and larger is called the **Thoracic Duct** which also receives all the lymphatics from the Intestines. Both open into veins and so the lymph is returned to the blood stream.

A **Lymphatic Gland** consists of a meshwork of fibres containing cells. Through this meshwork the lymph filters, and the passage of micro-organisms or cancerous cells along the lymphatic vessels is frequently arrested.

This explains the development of abscesses, of tuberculosis and of malignant growths in the lymphatic glands.

Lecture XV.

THE LIVER.

Anatomy.

The Liver is the largest gland in the body, weighing from 50 to 60 ounces. It is situated in the upper and right hand part of the abdomen immediately underneath the Diaphragm. At its left extremity it extends however across the middle line into the left side of the abdomen.

It is divided into two **Lobes,** a left and a right, of which the right is the larger.

It has a smooth covering of Peritoneum.

Blood flows to the Liver—

1st.—By the **Portal Vein.**

2nd.—By the **Hepatic Artery.**

Blood flows **from** the Liver by the **Hepatic Veins** which open into the Inferior Vena Cava.

Structure and Functions.

The Liver is made up of minute lobules composed of cells.

Each lobule receives a branch from the Portal Vein and a branch from the Hepatic Artery. These break up into **capillaries** among the cells. The capillaries again re-unite into **Venules** which finally unite together to form the Hepatic Veins.

Between the cells of the lobules are placed **minute ducts,** the **Bile Ducts,** and the cells, acting like glandular cells, manufacture **Bile** from the blood in the capillaries and turn it into the Bile Ducts.

These unite and re-unite into larger and larger ducts until one large duct, the **Hepatic Duct,** carries all the bile away from the Liver.

The Hepatic Duct unites with the **Cystic Duct,** coming from the Gall Bladder, to form the **Common Bile Duct,** which opens into the Duodenum by an orifice which is usually common to it and to the Pancreatic Duct.

The **Gall Bladder** is a bag attached to the under surface of the Liver towards the right side. It acts as a store house for Bile, especially during the period of fasting. Its duct is the Cystic Duct.

The Functions of the Liver are—

1st.—The **Secretion of Bile.**

2nd.—The **storing up of sugar** in the form of Glycogen. The blood in the Portal Vein contains an excess of dextrose after a carbohydrate meal and this is stored as Glycogen in the liver cells, and given out by them as required, in the form of sugar, into the blood.

3rd.—A waste substance called **Urea** is possibly formed in the Liver, to be afterwards expelled in the urine.

THE DUCTLESS GLANDS.

There are a number of glands in the body which have no ducts, but are nevertheless of vital importance to the organism.

Most of these **Ductless Glands** appear to manufacture secretions, called **Internal Secretions,** which are returned to the blood and, circulating in it, influence in different ways the functions of the body.

Knowledge of the Ductless Glands is still very imperfect. What is known has been ascertained by studying :—

(1) The results which follow disease of the glands ;

(2) The effects of the administration of extracts made from the same glands of lower animals.

Disorders of the body are produced when one or other of the glands produces either too much secretion or, on the other hand, too little or none at all.

The following are the most important of the Ductless Glands :—

The **Spleen,** situated in the upper and left hand part of the abdomen, immediately beneath the diaphragm. It weighs about 6 ounces.

Its function is not definitely known but it probably assists in the formation of the blood.

The **Thyroid Gland,** situated in the lower part of the neck in front. It consists mainly of two lobes, right and left, placed on either side of the trachea.

Removal or atrophy of the Thyroid Gland leads to the disease called Myxoedema, which again can be relieved by the administration of an extract of the thyroid gland of animals.

The disease known as Exophthalmic Goître is probably caused by an excessive production of internal secretion by this gland.

The **Thymus**, placed in the upper part of the Thorax immediately behind the Sternum.

It is well marked in the newly born and gradually shrinks until by puberty it has usually disappeared.

Its function is not known.

The **Pituitary Gland**, a small oval structure attached to the under surface of the brain and lodged in a bony hollow in the base of the skull.

Its internal secretion has a very important influence over the growth of the skeleton.

Thus over-secretion, if it occur in a young person, produces a giant. In older people it leads to the disease called Acromegaly.

Under-secretion on the other hand produces a failure of growth.

Administration of extracts of the pituitary gland of animals causes marked contraction of the involuntary muscles of the arteries, the intestines and the uterus.

The **Suprarenal Glands**, two small glands placed upon the upper ends of the kidneys.

Disease of the Suprarenals leads to a rare disorder called Addison's Disease.

Extracts of the glands produce marked contraction of the blood vessels.

The internal secretion of the adrenals appears to exercise a very important influence over the nervous system which governs the involuntary muscles.

The **Pancreas**, as described in Lecture XIV., is a secretory gland with a duct.

It acts however, in addition, as a Ductless Gland, producing an internal secretion which plays a most important part in the process by which any excess of sugar in the blood is stored in the liver.

In the disease called Diabetes Mellitus this process fails. An excess of sugar persists in the blood and passes into the urine. Very grave results follow.

From one part of the pancreas of animals a substance called Insulin has been extracted, which, when injected into the human body, increases the storing of sugar in the liver, and thus decreases the sugar in the blood.

In accordance with this it has been found that the repeated administration of Insulin to patients suffering from Diabetes completely relieves them of their symptoms.

Many other glands, and especially the genital glands, produce internal secretions which influence in decisive ways the growth, development and well being of the body.

But the amount of exact knowledge which we possess of the internal secretions is still small.

Lecture XVI.

RESPIRATORY SYSTEM.

Anatomy of the Respiratory Organs.

The air in respiration passes to and fro along the **Respiratory Tract** which is a long passage made up of the following parts in succession.

Nasal Cavities.
Pharynx.
Larynx.
Trachea.
Bronchi.
Bronchioles.
Air Cells.

The **Nasal Cavities** are two cavities situated between the Superior Maxillæ and separated from one another in the middle line by a thin partition, the Septum Nasi.

They are lined throughout by a mucous membrane, by which the air is warmed and moistened.

In front they open to the exterior by two openings, the Anterior Nares. Behind they open into the Pharynx through the Posterior Nares.

The roof of the Mouth forms the floor of the Nasal Cavities.

The **Pharynx** is a cavity situated behind the Nasal Cavities and Mouth.

Its upper part is called the Naso-Pharynx and into this the Nasal Cavities open.

The Larynx and Œsophagus open out of the Pharynx below.

The **Larynx** is a tube which opens out of the lower and front part of the Pharynx.

Its walls are made up mainly of two cartilages. The upper and larger called the **Thyroid Cartilage** gives rise to the prominence in the neck known as "Adam's Apple." The lower the **Cricoid Cartilage** is a complete ring.

These two are joined together by fibrous and elastic tissue which fills up the gap between them. The firm cartilage keeps the tube of the Larynx always open.

Two elastic bands called the **Vocal Cords** are stretched across the tube. These can be brought together or separated by muscles, and the passage of air between them, when they are close together, produces the vocal sounds.

The Larynx is continued on as the **Trachea,** a tube the walls of which are made up chiefly of rings of cartilage which are incomplete behind and are therefore C shaped. They are joined together by fibrous tissue and, as in the Larynx, their stiffness maintains the patency of the tube.

The Trachea runs down from the Larynx through the neck into the Thorax and divides into two **Bronchi,** one to each Lung.

Each Bronchus divides and sub-divides into smaller and smaller **Bronchioles,** which finally open into very minute cavities called **Air Cells.**

The Air Cells are lined by thin flat cells beneath which lies a meshwork of capillaries, and thus the air is brought very near to the blood stream and an interchange of substances is easily carried out.

The **Lungs** are made up mainly of the Bronchi, Bronchioles, Air Cells and Blood Vessels, with a certain amount of fibrous and elastic tissue binding them all together. They are covered with a shiny serous membrane, the **Pleura,** which also lines the inner surface of the Thorax, and thus allows the Lungs to move quite smoothly.

The Lungs with the Heart almost entirely fill the cavity of the Thorax, and each Lung is divided into **Lobes** the Right Lung into three lobes and the Left into two. The Left Lung is deeply indented so as to make space for the Heart.

The blood reaches the Lungs by the **Pulmonary Arteries** Right and Left, which are the branches of the main Pulmonary Artery.

The blood they contain is **venous.**

The blood returns by the **Pulmonary Veins** into the Left Auricle, the blood being **arterial.**

In Respiration the **air passes normally** through the Nasal Cavities, then through the Pharynx to the Larynx. Thence through the Trachea, the Bronchi and the Bronchioles to the Air Cells in the Lungs, and returns by the same route.

Movements of Respiration.

By the movements of Respiration air is drawn into and then expelled from the Lungs.

These movements continue throughout life, even in a state of unconsciousness. They are involuntary. Their cessation speedily results in death.

By the movement of **Inspiration** the cavity of the Thorax is enlarged, and air is drawn into the lungs, just as air is drawn into a bellows when its cavity is enlarged.

This is effected :—

1st.—By the **raising of the ribs** chiefly by the External Intercostal Muscles which pass from one rib to the next and are attached to both. As a result of their contraction the ribs are raised and the Thorax made wider and deeper.

2nd.—By the **descent of the Diaphragm** as the result of its contraction. This increases the height of the Thorax. The abdominal wall is at the same time pushed forward.

By the movement of **Expiration** the cavity of the Thorax is diminished and air is driven out of the Lungs.

This is effected :—

1st.—By the **depression of the Ribs** chiefly by the contraction of the Internal Intercostal Muscles aided by the muscles of the abdomen.

2nd.—By the **ascent of the Diaphragm** when it relaxes. With this there is a corresponding falling back of the abdominal wall.

In ordinary Inspiration and Expiration 30 cubic inches of air are drawn in or expelled, and this air is called **Tidal Air.**

After Expiration 200 cubic inches of air are left in the lungs, and this is called **Stationary Air.**

Changes in the Air and in the Blood in Respiration.

Atmospheric Air consists of two gases, **Nitrogen** and **Oxygen,** in the proportion of 79 parts of Nitrogen and 21 parts of Oxygen in 100 parts.

Nitrogen is an inert gas, while Oxygen is essential to life.

Atmospheric Air also contains a small trace, usually ·04 per cent. of a third gas, Carbon Dioxide.

In the Air Cells the blood absorbs Oxygen from the air by means of the Hæmoglobin in the red corpuscles, and it gives off into the air Carbon Dioxide equal in amount to the Oxygen which has been absorbed.

It also gives off **Water,** certain **organic impurities** and **heat.** The blood changes from **dark venous** to bright **arterial** blood.

Expired air therefore when compared with inspired air—

1st.—Contains **more Carbon Dioxide.**
2nd.—Contains **less Oxygen.**
3rd.—Contains **more water.**
4th.—Contains certain **organic impurities,** and
5th.—Is **warmer.**

The changes which occur in the blood on its passage through the lungs are the reverse of these.

The Blood **loses Carbon Dioxide, gains Oxygen, loses Water, loses certain organic impurities,** and **loses some heat.**

Lecture XVII.

THE EXCRETORY SYSTEM.

THE KIDNEYS.

Anatomy.

The Kidneys are **excretory** glands situated, one on each side, in the upper and posterior part of the abdomen.

The right is a little lower than the left.

They have a characteristic shape, the outer border being convex and the inner concave.

They are about 4 inches long, and each weighs about 4 ozs.

Blood is carried **to** the Kidneys by the **Renal Arteries** branches of the Abdominal Aorta.

Blood is carried **from** them by the **Renal Veins,** which open into the Inferior Vena Cava.

The **Urine** which each secretes is carried away by a tube called the **Ureter.** The two ureters run down the back of the abdomen, then through the pelvis and open into the Bladder.

Structure and Function.

The Kidneys are covered by a fibrous **Capsule** loosely attached to the surface.

The substance of the kidneys consists mainly of an enormous number of minute tubes, the **Uriniferous Tubules,** which, after a tortuous course, unite together and finally open into a cavity called the **Pelvis** of the kidney, out of which the Ureter opens.

The uriniferous tubules are, at their commencement, surrounded by a meshwork of capillaries derived from branches of the Renal Artery and the cells of the tubules **separate the Urine** from the blood and turn it into the tubules. Through these it passes into the pelvis of the kidney and so into the Ureter.

From the Ureter it passes into the Bladder to be expelled from the body.

The cells of the uriniferous tubules act therefore like **glandular cells** in picking substances out of the blood and turning them into a tube. But the substances they pick out are **waste substances** which are forthwith expelled from the body and the kidneys are therefore **Excretory Glands.**

The Bladder is a muscular and fibrous bag situated in the front part of the Pelvis.

It acts as a reservoir for the Urine which flows into it from the Ureters.

The Urine is periodically expelled from it through the Urethra a tube which opens out of the bladder.

This opening is guarded by a Sphincter or encircling muscle which keeps it closed except when micturition is about to occur. The muscle then relaxes.

Composition of Urine.

The Urine, the excretion of the kidneys is composed of—

1st.—Water.

2nd.—A solid waste material, called **Urea.**

This constitutes by far the greater part of the solid substances dissolved in the water of the urine.

The ammoniacal smell of decomposing urine results from the formation of ammonia by the action of microbes on Urea.

3rd.—A small quantity of another solid substance called **Uric Acid** also in a state of solution.

4th.—Certain salts, one of which being acid gives the urine its normal reaction.

The average amount of urine excreted per diem is 50 to 60 ounces.

The normal reaction is **acid** but it may be neutral or alkaline in states of health.

The average **specific gravity** is 1020, but both the quantity and the specific gravity vary very much in health. The chief cause of this variation is the varying secretion of sweat.

THE SKIN.

The skin forms a covering for the body and is continuous at the different orifices with the mucous membranes lining the internal tubes and cavities of the body.

Structure.

It is made up of **Epidermis** on the surface and **Dermis,** or "true skin" underneath.

The **Epidermis** is composed of cells. Those on the surface are flattened and horny, and are continually being worn off and their place taken by those beneath.

There are no blood vessels or nerves in the epidermis but the hairs and the ducts of the sweat glands pass through it.

The **Dermis** is raised into papillæ on its surface. It is composed of fibrous and elastic tissue and contains the **sweat glands,** whose ducts pass in a corkscrew fashion through the epidermis to open on the surface.

The Dermis also contains the **roots of the hairs** and the **sebaceous glands** and has blood vessels and nerves.

A **Hair** consists of a **root** and a **shaft** or stem. The root is embedded in a sac called the **hair follicle.**

The sebaceous glands open into the hair follicles and secrete an oily substance.

The **Nails** are formed by the thickening and hardening of the deep layers of the epidermis.

The Functions of the Skin are—

1st.—**It covers and protects the body,** shielding it from small injuries and preventing the entrance of micro-organisms.

2nd.—It can **absorb a little water** (and also some drugs, e.g., mercury).

3rd.—It acts very slightly as an **excretory organ.** Sweat consists almost entirely of water, but some drugs, and, in rare instances, urea, are excreted in it.

4th.—**It regulates the heat of the body** mainly by means of the sweat secreted.

If the sweat evaporates immediately it appears on the surface, it is never perceptible and is called **insensible perspiration.** If it collects in sufficient quantity to be visible as moisture it is called **sensible perspiration.**

In warm weather or after exertion, the vessels of the skin dilate, the surface becomes warm and much sweat is secreted. Unless the temperature of the air is actually higher than that of the body the latter loses heat, but the chief factor in cooling it is the evaporation of the sweat on its surface.

In cold weather the vessels of the skin are contracted, its surface is cold and very little secretion of sweat occurs. The loss of heat from the skin is very slight and is hardly at all increased by the evaporation of sweat.

ANIMAL HEAT.

Cold blooded animals are those whose temperature varies with the temperature of their surroundings such as most fishes.

Warm blooded animals maintain an even temperature under all circumstances and in all climates. This is effected by a proper regulation of heat production and heat loss.

In man the average temperature of the body is **98·4 degrees Fahrenheit.**

Heat is produced chiefly in the muscles by their contraction.

Heat is lost—

1st.—**By the skin** (a) by the evaporation of sweat, and (b) directly to its surroundings.

2nd.—**By the Lungs,** expired air being warmer than inspired air.

3rd.—**By excretions** such as the urine and fæces.

If more heat be produced then more heat must be lost or the temperature will rise.

Increase in the loss of heat is brought about by the **skin,** as described above, and by the **lungs,** deeper and quicker respiration taking place.

After violent exertion the skin becomes warmer, sweat is secreted freely and respiration is quickened. All these help to get rid of the extra heat produced, and they do so, so effectually that there is no rise in the body temperature.

Lecture XVIII.

THE NERVOUS SYSTEM.

The **Nervous System** consists of—
The **Brain.**
The **Spinal Cord** and
The **Nerves.**

Of these the Brain and its continuation the Spinal Cord constitute the **Central Nervous System** which controls and regulates all the movements and functions of the body.

The **Nerves** are solid cords which come off from the Brain and Spinal Cord and pass to every part of the body. They thus bring the Central Nervous System into communication with the whole organism and enable it to exercise its function of supreme control.

THE BRAIN.

Anatomy.

The Brain is a large organ, weighing from 40 to 60 ozs., which almost completely fills the Cranial Cavity.

It is covered by three membranes called the **Meninges.** Of these the **Pia Mater** is a fine smooth membrane which immediately covers the surface of the Brain, while the **Dura Mater,** which is thick and strong, lines the interior of the Skull.

Between these membranes there is a small quantity of a clear fluid, the **Cerebro-Spinal Fluid,** which acts as a water cushion for the brain.

The Brain consists mainly of two parts.

The **Cerebrum** which forms the main bulk of the organ and

The **Cerebellum** situated below the posterior part of the Cerebrum.

The **Cerebrum** is divided by a deep central cleft into two halves called the Right and Left Hemispheres, which are connected together at the bottom of the cleft by a large transverse band of brain tissue.

Each hemisphere is divided by clefts or fissures into **Lobes,** which correspond roughly to the bones under which they lie, and are called by the same names. Thus each hemisphere has a Frontal, a Parietal, a Temporal and an Occipital Lobe.

The surface of each lobe is thrown into folds or **Convolutions** by a complicated system of fissures.

These folds greatly increase the area of the surface of the Brain.

In the interior of the Cerebrum there is a series of cavities called the **Ventricles** of the Brain, which contain cerebro-spinal fluid.

The **Cerebellum** is much smaller than the Cerebrum and is attached to it below and behind.

Its surface is thrown into numerous small folds by a number of parallel clefts.

Structure and Blood Supply.

The Brain is a soft friable organ composed almost entirely of **Nervous Tissue.**

Nervous Tissue consists of nerve cells and of nerve fibres which branch from the cells and are, in many cases, of great length. Thus the fibres branching from some of the cells of the surface of the brain extend through the whole length of the brain and spinal cord.

The Nervous Tissue of the Central Nervous System is of two kinds called respectively **Grey Matter** and **White Matter.** In Grey Matter nerve cells predominate, White Matter is composed almost entirely of nerve fibres.

The surface of the Brain, or "Cortex," consists of a thick coating of Grey Matter, while the interior is composed of White Matter. Thus in the Brain, the Grey Matter surrounds the White Matter.

The Brain has a very free supply of blood carried to it mainly by the two Internal Carotid Arteries.

Blood flows from the Brain into the Cerebral Sinuses, large venous passages situated between the layers of the Dura Mater and running in grooves on the inner surface of the Skull. The blood from these flows onwards into the Internal Jugular Veins.

Functions of the Brain.

The following are the main functions of the Brain :—

I. It is the organ of the **Mind,** the seat of consciousness, the emotions, the will, intelligence and memory.

There are, no doubt, special parts of the brain in which these processes occur, but very little is known as to their exact position.

Injury, disease or drugs may alter or destroy the above functions, until in extreme cases these is complete unconsciousness, all the faculties of the mind being in total abeyance. This condition is called Coma.

II. It is the organ of **intelligent sensation.**

Impressions made on the surface of the body or arising in its interior are carried by the nerves to the brain, and there give rise to the different sensations of which we are capable, such as sight, hearing, taste, pain, touch, etc.

In this way we are brought into intelligent relationship with the outside world.

Most of the nerve fibres which carry these impressions to the brain cross over to the other side in the base of the brain.

Thus injury or disease of one side of the brain will give rise to loss of sensation or **anæsthesia** of the other side of the body.

III. It is the organ of **intelligent voluntary movement.**

Impulses started by the will pass down the nerves to the muscles and excite them to contract, thus giving rise to movement.

It has been found that the voluntary movements of the body originate in one particular part of the brain ; namely, certain convolutions of the frontal and parietal lobes. This part of the cortex is called the **Motor Area.**

Further each limb and part of the trunk has its own special centre in this area.

The nerve fibres from the Motor Area cross to the other side in the base of the brain before passing through the spinal cord and nerves to the muscles.

Thus injury or disease of one side of the brain gives rise to loss of power or **paralysis** of the other side of the body.

The movements concerned in **Speech** are however controlled, in right handed persons, entirely by the left side of the brain. This appears to be associated with the greater skill of the right hand.

The **Cerebellum** as far as is known, is chiefly concerned with the proper regulation of movements.

Every movement, even the simplest, has to be properly regulated in order to be satisfactorily performed, while many voluntary movements involve the contraction of a large number of different muscles.

The Cerebellum appears to control the degree of contraction in each muscle, so that they all work together in harmony.

Lecture XIX.

NERVOUS SYSTEM (continued).

THE SPINAL CORD.

The Spinal Cord is a continuation of the Brain.

It is a cylindrical cord which extends from the Foramen Magnum downwards along the Spinal Canal as far as the first Lumbar Vertebra.

Its length is about 18 inches and its thickness that of the little finger.

The Spinal Cord is covered by three membranes, the Meninges. These are continuous with the similar membranes covering the Brain.

The Spinal Cord like the Brain is composed almost entirely of nervous tissue, but, in the case of the Cord, the Grey Matter which contains the nerve cells is surrounded by the White Matter.

The Spinal Cord gives off 31 pairs of nerves called Spinal Nerves. These branch from the sides of the Cord.

Functions of the Spinal Cord.

The Spinal Cord has two main functions :—

1st. Its nerve fibres conduct impulses passing to and from the Brain.

These impulses are of two kinds :—

1.—Those passing from the Motor Area downwards along the Spinal Cord and the Spinal Nerves to the Muscles.
These impulses give rise to movements.

2.—Those passing from the surface of the body or from its interior upwards through the Spinal Nerves and the Spinal Cord to reach the Brain.
These impulses give rise to sensations.

Destruction of the Spinal Cord by injury or disease prevents the passage of these impulses and gives rise to

paralysis and anæsthesia of the whole of the body below the level of the injury.

2nd. It is the centre for a number of **Reflex Actions.**

A Reflex Action is an action which results immediately from some stimulus applied to the body without any intervention by the Mind.

The stimulus gives rise to an impulse which passes up the nerve to a centre consisting of nerve cells. It there excites another impulse which passes down to a muscle or gland and gives rise to action.

A large number of such reflex actions occur in the normal working of the body, the Brain as well as the Spinal Cord containing a number of reflex centres.

Reflex Action results in some cases in muscular contraction and, in others, in active secretion by a gland.

Thus tapping the patellar ligament gives rise to a contraction of the thigh muscle which is called the "Knee Jerk."

The presence of food in the mouth reflexly excites secretion by the gastric glands.

The movements of respiration are themselves the result of a reflex action whose centre is in the lower part of the brain. Destruction of this centre leads to cessation of respiration and rapid death.

THE NERVES.

The **Nerves** are solid cords which come off from the Brain and Spinal Cord and pass to all parts of the body, branching and re-branching and providing every tissue and organ with its due nerve-supply.

Each Nerve consists of a compact bundle of Nerve Fibres which are of two kinds, **Motor** and **Sensory.**

Motor Fibres carry impulses from the brain and spinal cord to the muscles. These impulses make the muscles contract and so produce movements.

Sensory Fibres convey impulses from the surface of the body and the internal organs to the brain.

These impulses give rise to sensations.

Some nerves contain only motor fibres, some only sensory fibres, while many contain both varieties and are called mixed nerves.

The fibres in a nerve are bound together by connective tissue, and the whole nerve is enclosed in a thin fibrous sheath.

The Nerves have only one function namely to conduct impulses to and from the central nervous system.

They constitute the great organ of communication of the body.

Cranial Nerves.

The Brain gives off 12 pairs of nerves.

These are called **Cranial Nerves** and are numbered I to XII.

They come off from the lower surface or **base** of the Brain and pass out through foramina of the skull.

They comprise the nerves of special sense and also those supplying movement and sensation to the face and mouth.

The 1st pair are the **Olfactory Nerves,** the Nerves of Smell.

The 2nd pair are the **Optic Nerves,** the Nerves of Sight.

The 3rd, 4th and 6th pairs are motor nerves which supply the muscles which move the Eyeball.

The 5th pair are the Nerves which supply the Face with sensation and also supply the muscles which close the jaw.

The 7th pair are the **Facial Nerves** supplying the muscles of the Face, including the Eyelids and Mouth.

The 8th pair are the **Auditory Nerves,** the Nerves of Hearing.

The 9th pair are the Nerves of Taste.

The 10th pair are the two **Vagus Nerves,** very important nerves which supply the Lungs, Heart, Stomach and other Viscera.

Spinal Nerves.

The Spinal Cord gives off 31 pairs of Nerves which are called **Spinal Nerves.**

They pass out through foramina between the Vertebræ.

They are all mixed nerves containing both motor and sensory fibres.

They supply motion and ordinary sensation to the whole of the body with the exception of the Face and Mouth.

The most important nerves of the **Upper Extremity** are :—

1st.—The **Musculo Spiral Nerve** which winds round the Humerus, and supplies the muscles which extend the Elbow and the Wrist.

2nd.—The **Ulnar Nerve** which passes behind the Internal Condyle of the Humerus, and with

3rd.—The **Median Nerve** supplies the muscles which flex the Wrist. The Ulnar Nerve also gives sensation to the inner side of the Hand.

In the **Lower Extremity** the most important nerve is the **Great Sciatic Nerve** which runs down the back of the Thigh, from a point midway between the Great Trochanter and the Tuberosity of the Ischium. It and its branches supply the muscles of the back of the thigh and the muscles of the leg. They also supply sensation to the skin of these regions.

The **Phrenic Nerves** are two most important Spinal Nerves which are situated in the neck and Thorax.

They are the nerves of supply to the **Diaphragm** muscle, and are therefore essential to the movements of Respiration.

Lecture XX.

THE SENSES.

We are able, when conscious, to distinguish a number of different sensations or feelings.

This fact is usually expressed by saying that we possess a number of "**senses.**"

It is by means of these senses that we become aware of what is happening around us.

The senses usually recognized are **sight, hearing, taste, smell, touch, pain, heat and cold,** and the **muscular sense.**

In addition to these, hunger, thirst and fatigue, although distinctive sensations, are too indefinite to be classified among the senses.

The senses of sight, hearing, taste and smell are confined to special organs devoted entirely to their production.

The other senses are not confined to localized organs but are distributed widely through the body.

Every organ of sense consists of three parts :—

1.—Nerve ends which receive the impressions and turn them into impulses.

2.—Sensory nerve fibres which transmit these impulses to the brain.

3.—A nerve centre in the brain which converts the impulses into sensations.

An organ of sense can produce only one kind of sensation.

Thus stimulation of the organ of sight by, for instance, a blow on the eyeball, will produce sensations of sight only and not of pain or any other sense.

And the same rule applies to all the sense organs. Each can only attend to its own business.

Sight.

The **organ of sight** consists of the **eyeballs** which receive the impressions of light, the **optic nerves** which transmit the resulting impulses, and centres in the brain where the impulses are turned into sensations.

The **Eyeball** is a globular organ lodged in the orbital cavity.

It is surrounded by six muscles, by which its movements are effected. The orbital cavity also contains blood vessels and nerves, the lachrymal gland, and a packing of fat.

In front, the eyeball is covered by the two eyelids which can be closed over it by the contraction of a circular muscle.

The inner surface of the eyelids and the front of the eyeball are lined by a smooth membrane, the **conjunctiva.**

This is kept in a moist state by the **tears,** the secretion of the **lachrymal gland.** Any excess of fluid is drained away into the nose by a small duct, the **nasal duct.**

The eyeball itself is a hollow globe with the front part bulging a little forward. Its diameter is about one inch.

Its wall consists of three coats.

1.—An outer coat formed behind by the strong opaque **sclerotic,** and in front by the circular transparent **cornea** which projects forwards from the curve of the eyeball.

2.—A middle coat formed by the dark pigmented **choroid,** containing many blood vessels.

In front the choroid is not complete. It is continued as the circular, coloured **iris,** in the middle of which is a round aperture called the **pupil.**

The iris is muscular and can be contracted or relaxed, thus varying the size of the pupil.

3.—The inner coat is the **retina.** This is formed by the optic nerve, which enters the eyeball behind, passes through the outer and the middle coat, and then splits into its fibres which spread out in every direction to form the retina.

The retina lines the inner surface of the choroid only.

Immediately behind the iris is situated the **lens.** This is a soft, transparent body which has the same shape as a a doubly convex lens, that is, one which bulges on both surfaces.

By means of the action of a muscle, the **ciliary muscle,** the degree of convexity of the lens can be varied.

The lens divides the cavity of the eyeball into two parts.

The front part, called the **anterior chamber,** is situated between the cornea and the lens. It contains a watery fluid, the **aqueous humour.**

The cavity behind the lens is called the **posterior chamber.** It contains a gelatinous substance, the **vitreous humour.**

The **optic nerves** come off from the base of the brain and pass through bony foramina into the orbits.

They then enter the eyeballs behind and spread out to form the retinæ.

Images of external objects are formed on the retina by the lens, just as the lens of a camera produces images on the plate.

In both cases the external object must be illuminated before an image can be produced.

The formation of an image on the retina stimulates the nerve ends, which produce corresponding impulses.

These impulses pass up the optic nerves to the brain and there produce the sensations of sight.

By varying the convexity of the lens we are able to produce clear images of both near and far objects.

This is effected by the ciliary muscle and is called the power of **accommodation.**

The amount of light which enters the eyeball depends on the size of the pupil which can be increased or diminished by the dilatation or contraction of the muscular iris.

In bright light the pupil contracts, while in dim light it dilates.

This reaction of the pupil to light is called the **light reflex.**

The pupil also contracts when near objects are looked at and dilates when the vision is fixed on distant objects.

This is called the **accommodation reflex.**

Hearing.

The **organ of hearing** consists of the **ears** which receive the impressions of sound, the **auditory nerves** which convey those impressions in the form of impulses to the brain, and centres in the brain, where the impulses become sensations of hearing.

The **ear** is made up of the external, the middle and the internal ear.

The **external ear** consists of the **pinna** projecting from the side of the head, and the **auditory canal.**

The latter is a tube formed first of cartilage and then of bone which passes inwards and terminates at the **membrana tympani** or drum, a membrane tightly stretched across the canal.

The **middle ear** or **tympanum** is a small cavity in the temporal bone. It contains air.

Its outer boundary is formed by the membrana tympani.

A chain of small bones, the **ossicles,** stretches across the middle ear from the drum to the internal ear.

The middle ear is connected to the pharynx by a tube, the **eustachian tube,** and is thus brought into communication with the outside air.

The **internal ear** consists of a series of small canals and cavities in the bone, which are filled with fluid and are lined by a membrane containing the ends of the branches of the auditory nerves.

Sounds produce vibrations of the ear-drum.

These vibrations are transmitted by the ossicles to the internal ear where they stimulate the nerve ends.

The latter convert the stimuli into impulses which pass up the auditory nerves to the brain centres and are there converted into the sensations of sound.

Smell.

The sense of **smell** originates in the mucous membrane of the upper part of the nasal cavities which contains the nerve ends of the branches of the **olfactory nerves.**

These nerve ends are stimulated by odours and the resulting impulses pass up the olfactory nerves to the brain and produce the sensations of smell.

Taste.

Impressions of **taste** are received by the **taste buds,** minute oval bodies scattered through the mucous membrane of the tongue and soft palate.

The upper surface of the tongue is rough, being covered by small elevations called **papillæ.**

At the back of the tongue there is a number of large papillæ and it is around these that the taste buds are most numerous.

The taste buds are the enlarged ends of the branches of the **glossopharyngeal nerves,** the 9th pair of cranial nerves, which carry to the brain the impulses which produce the sensations of taste.

Before any substance can be tasted it has to be dissolved either when placed in the mouth or by the saliva. Quite dry substances are tasteless.

Further, the sense of taste is very largely dependent on the sense of smell and becomes very defective when smell is lost.

Touch, Heat, Cold, Pain.

The whole surface of the body is sensitive to these impressions.

The sensory fibres of the nerves to the skin end in minute enlargements, generally oval in shape and situated in the dermis.

Those which serve the sense of touch are called **touch corpuscles.**

There are separate nerve ends and nerve fibres for each of the four senses and the corresponding impulses pass up the nerve fibres to the brain.

These sensory fibres are present in all the spinal nerves and in some of the cranial nerves.

In the case of the spinal sensory fibres, the impulses are carried to the spinal cord, through which they pass to reach the brain.

In various centres in the brain the different sensations of touch, heat, cold and pain are produced.

We are able not only to feel the sensations but also to locate the exact part of the body which has received the stimulus.

The senses of touch, heat and cold are definitely developed only in the skin and in the mucous membrane of the mouth.

The sense of pain on the other hand is widely distributed through every part of the body.

Muscular Sense.

This is the sense which enables us to estimate the degree of contraction of the muscles.

It depends on impulses passing from the muscles to the brain and there giving rise to sensations which are only rarely conscious sensations.

The possession of this sense makes us capable of estimating the weights of objects, and of regulating the contraction of the muscles so that they work together in harmony.

It is also by the aid of this sense that we can tell the position of our limbs and can balance the body when performing movements of all kinds.

All these faculties depend however, not only on impressions from the muscles, but also from the skin, the joints and probably the internal ear.

We are to a very large extent unconscious of the existence of the muscular sense although it is only by its aid that we can carry out any action with precision.